APPENDIX J

Memo

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SUBJECT: Technical Memorandum
Underpinning/Reinforcement
Reno Rail Corridor Project
Reno, Nevada

UNDERPINNING/REINFORCEMENT OF EXISTING STRUCTURES

General

The proposed Reno Railroad project alignment will result in excavation support systems being constructed close to, or below, the foundation elements for a number of existing structures along the alignment. The impact of the construction and the performance of excavation support systems on the existing buildings must be considered during the design stage. If the evaluation indicates that the existing foundation elements will undergo unacceptable deformations or reductions in support capacity, then underpinning or reinforcement of the existing foundations may be required. This technical memorandum describes alternative methods for accomplishing the underpinning. Structures that will require underpinning during construction include the Hilton parking garage, Amtrak Station and possibly the Sands pedestrian over pass, south of the trench, may also require temporary or permanent underpinning.

Excavation Effects on Bearing Capacity of Existing Foundations

Reduction of foundation bearing capacity due to the construction and long-term presence of excavation support systems can occur for any existing foundation that falls within the influence zone of soil providing shear resistance to the foundation loads. The ultimate bearing capacity for footings and end-bearing caissons, adjacent excavations within a horizontal distance of about 2B, (where B is the width of the footing or caisson), can be reduced. A reduction in the bearing capacity may be accompanied by settlements of the foundations relative to the adjacent ground. For end bearing pile groups, the footprint of the pile group at the top of the bearing layer should be considered as a footing, and the potential reduction in group bearing capacity evaluated. If friction piles are used, the equivalent “footing” should be assured at approximately mid-depth along the piers. Utilities located within a horizontal distance of 1.5 times the excavation height may also be candidates for underpinning, although most such (if not all) utilities will be relocated prior to trench construction.

Excavation Ground Movement Effects on Adjacent Structures

Evaluation of the impact of ground movements on adjacent structures should consider both total and differential vertical and lateral movements. The most significant effects on adjacent structures are likely to result from distortion of the structures, both due to differential settlements and differential lateral movements. Differential ground settlements will directly affect footings, piles, or caissons supported above the base of the support system excavation. Ground settlements may also create downdrag loads on deep foundations. Lateral stretching can affect structures with both deep and shallow foundations. For structures supported on heavy mat foundations, differential ground movements may result in redistribution of bearing pressures on the base of the mat, increases in mat bending stresses, and tilting of the structure.

The designer should evaluate the effects of estimated ground movements on each individual substructure, superstructure, and connecting utility. All structures and utilities within a horizontal distance of 1.5 (H), where H is the depth of the adjacent trench excavation, should be evaluated

Methods for Reducing Excavation Support Ground Movements

The use of relatively rigid excavation support systems, such as braced slurry walls, can reduce the amount of ground movements acting on adjacent foundation systems. Proper excavation support system construction procedures can also reduce the effects of ground movements on adjacent foundation systems. Some common construction procedures recommended to control ground movements for various excavation support systems are:

1. Reduce ground movements during slurry wall installation by constructing effective guidewalls, limiting panel excavation lengths, using high density slurry, and maintaining high slurry levels.

2. Minimize overexcavation at the bracing levels and at the bottom of the excavation. Excavate and brace walls in short segments.

3. Minimize time between excavation to the bracing levels and installation of the bracing.

4. Use connection details and preloading techniques that eliminate slack in the excavation bracing system.

5. Monitor and maintain strut preloads.

6. Avoid removal of old foundations or obstructions adjacent to the inside face of the excavation walls until after bracing has been installed.

7. Minimize construction surcharge loadings next to the excavation, especially during the initial cantilever stage.

8. Control groundwater seepage through or under walls. Prevent loss of ground and ground deformations due to excessive seepage or lowering of groundwater levels.

9. Prebore holes for soldier piles or drilled shafts under slurry support to minimize ground losses. Properly place tremie concrete for soldier piles, drilled shafts, and walls.

10. Minimize thermal contraction and expansion of bracing.

11. Do not use temporary internal earth berms in lieu of bracing.

12. Avoid accidental damage of vertical wall supports and bracing struts during construction.

At critical locations, where the cost of building reinforcement or underpinning is prohibitive, internal slurry cross walls or T-sections should be considered. These cross walls or T-sections will stiffen and strengthen the perimeter slurry walls. The T-sections or cross walls can be removed in stages as the excavation progresses, and should be left in place below the bottom of the excavation. The spacing between the T-sections or cross walls will be determined by the ability of the slurry walls to function as a diaphragm, and the estimated ground movements due to bowing of the perimeter slurry wall between supports.

<u>Methods of Underpinning</u>

Underpinning should be used where estimated ground movements exceed tolerable movements for existing structures, or where stiffening or reinforcing of existing structures is not practical or economical. Some approaches to underpinning that may be considered for adjacent foundation system are discussed below. It should be recognized that the process of underpinning will result in some differential settlement of the structure, depending on the underpinning method and quality of workmanship. Also, most types of underpinning are intended to reduce vertical movement of a structure, but do little to reduce or prevent lateral movement of the structure. Reinforcing the soil sufficiently to reduce or prevent lateral movements of buildings adjacent to deep excavations can be difficult and costly.

1. Pit Underpinning

   Hand-excavated pit underpinning is most likely to be used where it is necessary to extend shallow footing foundations or utilities to a deeper bearing layer. Usually, underpinning pits are not used where the needed increase in depth is great, because of the time and cost of hand excavation. Underpinning pits are typically about 4 feet wide, and excavated one at a time with horizontal board lagging. Sump dewatering may also be required during pit excavation. Local shoring may be required to stabilize individual foundation footings during pit excavation. The underpinning pits should be backfilled with unreinforced concrete to a level about 2 inches below the bottom of the existing foundation. The gap should then be dry-packed with a moist, high-cement content mortar mix. Depending on the type and condition of the existing foundation footing, pit underpinning support can be continuous or intermittent. Pit underpinning generally should not be used for columns, unless the column load is temporarily removed from the footing by transfer beams and temporary footings. This method is most applicable for shallow utilities adjacent to the excavations.

2. Jet Grouting

Jet grouting could be used to create zones of cement-stabilized soil below the existing foundations extending to the depth required for underpinning. The grout is injected at very high pressures as a high velocity stream through small-diameter ports in the side of a rotating drill rod. The grout stream cuts and mixes the grout with the soil, leaving a cemented soil mass typically consisting of a somewhat irregular column from 2 to 4 feet in diameter. By proper spacing and sequencing of holes, a nearly continuous wall or large column of cemented soil can be created. Jet grouting can be performed in basements or confined space areas using small drill rigs and grout mixing and pumping equipment. This method is most applicable for support of the major structures discussed above, (Hilton parking garage, Amtrak Station).

3. Pin Piles

Drilled 5 to 12 inch diameter hollow steel pipe piles encased in grout can be used for support of column and wall foundations. Normally, the piles are installed on both sides of the column or wall, and transfer beams, needle beams, or brackets, are used to connect the existing column or wall to the new piles. The piles can be installed in basements and other tight spaces, using available drilling equipment. The piles may be designed for a combination of friction and end bearing in the soil below the zone of movement. This method is also applicable for the structures described previously.

<u>Reinforcement of Substructures of Adjacent Buildings</u>

As noted previously, adjacent buildings may be adversely affected by total and differential settlements as well as total and differential lateral movements. In general, the differential settlement and resulting angular distortion of the structure will be more important than the magnitude of total settlement for the structures along the alignment. Similarly, the differential lateral movements induced in a structure are usually more important than the magnitude of total lateral movement. In many cases, it may be possible to accommodate the estimated settlements and lateral deformations with relatively minor damage to a building substructure by reinforcing or stiffening the substructure of a building. Some possible methods for reinforcing the substructures of buildings are discussed below (Note that the following discussion is in regards to building substructures only, and not to superstructures):

A. For older buildings supported on spread footings, timber piles, or caissons, there is usually no structural connection between the foundation and the basement walls. In additional, there is usually no structural connection between the basement floor and first floor framing, and the basement walls. The basement walls are usually constructed of brick, granite block, mortared stone, or unmortared stone. For these buildings, the following types of evaluation, reinforcement, and repair of the substructure could be considered:

1. Install ties between walls at the first-floor level and at each framed basement floor level if any, especially in the direction perpendicular to the excavation;

2. Repair or replace severely deteriorated or missing mortar, install mortar in dry walls to secure potentially unstable foundation stones, pour a reinforced concrete interior and/or exterior facing wall to stabilize stone walls, or shore out-of-plumb or offset walls;

3. Evaluate the condition of timber piles where the condition is not known, and restore connection between the top of sound piles and the pile cap at buildings where the tops of the timber piles are deteriorated;

4. Evaluate the shear and bending induced in the foundation piles by differential lateral movement and introduce a horizontal sliding surface between the basement wall or columns, and the pile cap to permit lateral shifting, if appropriate; and

5. During and after construction, repair and seal cracks in the floor and basement walls and repair or replace basement floors as needed.

The magnitude of potential tilting of the basement walls below the first-floor level and/or the lateral shifting of footing blocks relative to the basement walls would not pose a structural threat to the supporting capacity of the substructure provided the walls are reasonably plumb prior to construction, and adequate ties are provided as noted above.

B. For buildings with reinforced concrete basement walls, and concrete footings, piles with concrete pile caps, or caissons with concrete grade beam foundations, there is usually a structural connection between the foundation elements and the basement walls or grade beams. Also, the first floor and any basement floors are usually structurally connected to the basement walls. The lowest basement floor is usually a slab-on-grade and is not a structural element. For these buildings, the following types of evaluation and reinforcement of the substructure could be considered.

1. Evaluate the adequacy of the structural connections between the foundation elements, grade beams, basement walls, and floors to resist the estimated lateral loads, and provide additional reinforcing, if needed;

2. Evaluate the ability of the basement walls to withstand the estimated angular distortion, especially if they are structural bearing walls, and provide reinforcing or alternate load pathways to the foundation, if needed;

3. Evaluate the shear and bending induced in the foundation piles by differential lateral movement, and introduce a horizontal sliding surface between the basement wall or columns, and the pile cap to permit lateral shifting, if appropriate; and

4. During and after construction, repair and seal cracks in the substructure and basement floor and repair or replace the basement floor, as needed.